U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **Mary A. McGonagle** **Proposal No.: 01-005**

Institution: **Massachusetts Institute of Technology**

Title: **High Performance Fuel Design for Next Generation PWRS**

All current PWR units worldwide employ fuel of very similar design: cylindrical pins of about one centimeter diameter in a lattice with a water-to-fuel volume ratio of about 1.7. Evolutionary improvements have been implemented over the past decades, but with small incremental benefits. The concept proposed for investigation here, however, would provide substantial qualitative safety improvements: for example a 1000 °C reduction in peak fuel temperature at the hot spot and a very mild fuel response in LOCA, while simultaneously allowing an appreciable increase of power density (by 30% or more) and significant economic benefits.

The objective of this project is to develop and optimize the design of internally and externally cooled annular fuel to achieve a significant increase of core power density while improving safety margins. This will appreciably reduce capital cost per installed kW as well as operating and fuel cycle cost per unit energy produced. In addition, core design and fuel performance analyses will be performed to maximize fuel burnup utilizing the benefits of very low operating fuel temperature and wetter lattices to further improve fuel cycle economics. While aimed at new Generation IV reactor applications, retrofit version for current PWRs will also be examined.

This proposal addresses primarily the nuclear technology areas of (1) advanced nuclear fuels for PWRs and (2) generation IV nuclear systems, both with emphasis on significant improvements in safety and economy, and to a lesser extent the nuclear technology areas of (3) waste management and (4) proliferation resistance, through the achievement of high burnups and changing the core characteristics to produce less and dirtier plutonium.

The work will be led by MIT, the organization that conceived and initiated the development of this idea. MIT will perform neutronic and hydraulic optimization of the design, fuel cycle analyses and irradiation tests of prototypical fuel segments. Together with industrial partners, ways to reduce manufacturing costs and overall plant economics will be evaluated. The major collaborating organization will be Gamma Engineering Corporation, that will be responsible for optimizing the fabrication and characterization of the new fuel elements using subcontracts to North American based commercial nuclear fuel suppliers and ceramic research firms, and Westinghouse Electric Corporation that will evaluate the quality and cost of the fabrication process of the new fuel, and its impact on plant economics. Duke Engineering & Services will examine the safety margins achieved by the new fuel design.
